DATA ON THE O_2-HOUSEHOLD AND PRIMARY PRODUCTION OF THE NAGYSZÉKTÓ LAKE NEAR KISTELEK (S. HUNGARY).

by

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The hydrographic properties of Hungarian sodic waters are consequences of the soil- and climatic characteristics of the Great Hungarian Plain. Climate is characterized by a wet-cold and a dry-warm season. The degree of evaporation, therefore, varies to a high extent: it is very low in winter and spring, and extremely high in summer and autumn. The annual precipitation of the Great Hungarian Plain is about 500 – 600 mm but in an uneven yearly distribution. Drought periods of 4 – 6 weeks are common in summer. Therefore the lakes and ponds of the Great Hungarian Plain are *astatic*.

In general the *depth* of the lakes does not exceed 1 – 2 m (with the exception of a few more extensive lakes) but long, shallow ponds of 0,1 – 0,2 m in depth and several kilometers in length are very common among them. The *temperature* of the lakes is characterized by extreme changes: their shallow water may become uniformly warm from top to bottom, up to almost 40 °C; in winter, on the other hand they may be frozen to their entire depth. Their temperature amplitude may thus exceed 50 °C or even more. *Chemically* sodic waters are characterized by an extreme concentration of Na_2CO_3 and $NaHCO_3$ as well as by a high variation in the concentration of dissolved salts. The *colour* and *transparency* of sodic waters also show great variation. These changes are due to the integral effect of chemical (precipitation of $CaCO_3$, solution of humic acids), biological (propagation of plankton-organisms, "blossoming" of the water) and meteorological (wind, rainfall etc) effects, but in all seasons the rays of the red spectral region penetrate into the deepest layers: below a certain depth only red light carries energy (D v i h a l l y, 1958, 1961, 1971). (Fig. 1.)

In consequence of all these factors a highly characteristic *biological community* develops in the sodic lakes. The members of this community are partly the compositian, ubiquitary species of wide ecological

valency, partly the polyhydrion constituents of the stenotope fauna and flora.

The chemical characteristics of sodic water show a marked *seasonal* change. The direct and indirect causes of the seasonal chemical changes are partly meteorological effects, partly the biological processes of the water. All carbonate-type sodic waters, even the most concentrated ones (e. g. Nagyszéktó at Kistelek) lose their sodium carbonate content in the winter period and transform into ones of low pH, not containing even the slighest amount of carbonate. This most interesting and highly characteristic phenomenon can be explained by the changes in free CO_2-concentration. The CO_2-concentration of the water slightly varies upon the effect of the CO_2-content of the atmosphere and of the rain; the main cause of CO_2-changes is, however, the photosynthetic activity of the phytoplankton organisms in the water. The decrease of assimilation and the preponderance of dissimilation in autumn and winter calls forth a high CO_2-content of the water, which gradually converts the total quantity of CO_3^{--} into HCO_3^-. After the appearance of free CO_2, tha Ca^{++}-content of the water increases; a tenfold or even higher increase of the Ca^{++}-content within a month is quite common during this period.

At the beginning of spring, the process becomes reversed: as the optimal conditions of light are approached, an intensity of assimilation sets in and simultaneously the quantity of assimilating organisms begins to increase, consuming the free CO_2 and later the equilibrium CO_2. The reaction between water, CO_2, and $CaCO_3$

$$CaCO_3 + H_2O + CO_2 \rightleftarrows Ca(HCO_3)_2$$

(being a reversible one) will now proceed in the direction of the lower arrow; the winter equilibrium between the components will be discontinued and $CaCO_3$ will precipitate. The quantity of Ca^{++} decreases and CO_2 resolved during $CaCO_3$ precipitation partly replaces the equilibrium CO_2. After the total consumption of the free-, as well as equilibrium CO_2, the stochiometric amount of $Ca(HCO_3)_2$ converts into $CaCO_3$, and (theoretically) there remains only a quantity of dissolved Ca^{++} in the water which corresponds to the solubility product of the $CaCO_3$ in the absence of free CO_2. In practice, however, the Ca^{++} content of even filtered sodic waters is slightly higher as a consequence of the very stable colloidal solution of $CaCO_3$ formed indirectly during assimilation. The increase of the CO_3^{--} and the simultaneous decrease of the Ca^{++} content are rather marked in all the investigated sodic waters. Also the total quantity of dissolved salts increases in consequence of evaporation, and an increase in Na^+ and a decrease in the other cations is observed.

In high summer the illumination is above the optimum, which causes a simultaneous reduction of assimilation and CO_3^{--}; at the end of summer illumination reaches its optimum (increase of assimilation

and CO_3^{--}). Finally, late in autumn illumination is sub-optimum, assimilation is reduced to a very low extent with all its consequences and the chemical conditions of the lake reach the already outlined winter ones (Table I.).

Besides seasonal changes, brisk diurnal ones can be observed, too (Table II.). The dissolved O_2-content of the water varies within wide limits. At the time of the investigation (4 – 5 June 1955) the water was generally supersatureted with O_2; only between 2 – 6 a. m. were the saturation percentages under 100%. Fig. 2.

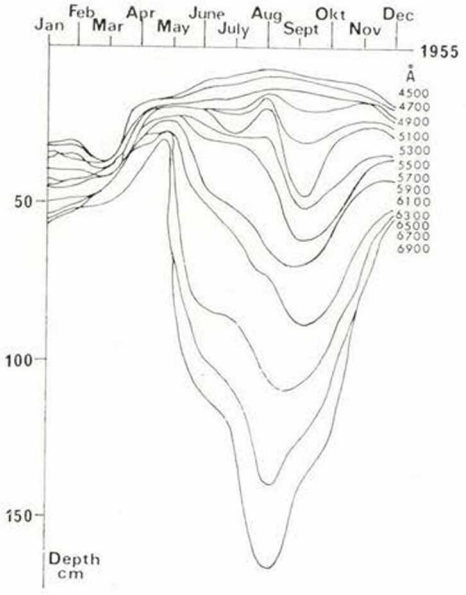

Figure 1. The penetration of several spectral regions into various depths of the water of Lake Nagyszéktó at Kistelek

Examinations were begun during the interval between the increasing and decreasing autochtonous phases (E r ő s 1954); the local minimum of the O_2-curve is due to super-optimum illumination -intensity (at 2 p. m. Central European Summer Time) (cf. M a u c h a 1955). Production stops and thus the decreasing autochtonous phase begins, at 8. p. m. The increased O_2 content of the water between 10 – 12 p. m. is of no biological significance, it is merely due to simple physical effect observed by several authors. This phase may be described as an increasing allochtonous one, and is caused by the cold night air which cools the upper layers of the water. Thus these layers sink gravitationally, and are soon exchanged by the warm water of the bottom

Table I.

Chemical conditions of Lake Nagyszéktó at Kistelek in 1955–1956 relying on monthly examinations.

Time of investigation	pH	Alkalinity [W°]	Hardness Ca + Mg [G°]	$Na^+ + K^+$ [mg/l]	Ca^{++} [mg/l]	Mg^{++} [mg/l]	CO_3^{--} [mg/l]	HCO_3^- [mg/l]	Cl^- [mg/l]	SO_4^{--} [mg/l]	Total dissolved salts [mg/l]
6.6.1955	10,4	33,7	15,4	792,4	6,7	62,9	401,1	1240,3	211,2	13,7	2728,3
25.7.1955	10,4	69,3	38,2	1552,9	15,0	156,6	920,9	2356,8	341,9	102,9	5487,0
30.8.1955	9,5	34,6	11,1	933,9	7,9	43,4	161,6	1723,3	305,3	110,9	3286,3
30.9.1955	10,1	44,3	16,8	1153,9	9,9	67,2	496,9	1693,0	352,2	92,4	3865,5
22.10.1955	9,9	53,3	25,9	1395,7	12,7	104,5	623,3	1983,9	534,5	72,3	4726,9
17.11.1955	9,1	26,2	28,7	667,8	9,5	118,8	228,3	1137,0	430,2	41,5	2633,1
17.12.1955	8,2	27,9	31,4	676,2	44,5	109,3	0,0	1700,1	430,2	27,8	2988,1
10.1.1956	8,0	26,9	31,9	445,6	56,2	104,3	0,0	1640,0	100,0	50,0	2396,1
27.2.1956	8,0	24,6	26,9	414,9	99,2	56,8	0,0	1498,0	55,7	73,1	2198,6
28.3.1956	9,1	13,1	18,7	201,5	17,9	70,3	106,5	580,5	32,0	70,2	1078,2
19.4.1956	9,6	24,8	19,6	529,0	12,8	77,2	121,8	1266,7	132,4	68,1	2208,0
24.5.1956	9,1	25,8	19,9	568,3	1,2	79,4	126,8	1316,8	159,0	47,3	2298,8

Table II.

Diurnal chemical investigations of Lake Nagyszéktó at Kistelek (4—5. 6. 1955).

Time [hr]	Wind	Cloudiness	Temperature		Difference (in favour of water)	O_2 content		Saturation cm^3/l	Saturation %	pH	Alkalinity W°	CO_3^{--} mg/l	HCO_3^- mg/l
			air [C°]	water [C°]		[mg/l]	[cm^3/l]						
12	1	6—7	27,0	18,5	−8,5	16,7	11,7	6,61	177,9	10,10	33,3	437,6	1143,3
14	2 NWW	3—4	22,5	24,0	+1,5	11,7	8,4	5,89	143,5	10,10	34,6	430,8	1233,6
16	1 NWW	7	22,5	24,5	+2,0	15,4	10,8	5,83	186,1	10,21	33,8	439,6	1170,8
18	2 NWW	9	22,0	24,5	+2,5	13,3	9,5	5,83	162,9	—	34,1	358,5	1348,9
20	2 W	6—7	19,0	23,3	+4,3	14,1	9,9	6,00	165,8	10,33	34,1	374,1	1317,2
22	—	full moon (no clouds)	16,0	22,0	+6,0	12,0	8,4	6,11	138,3	—	31,9	270,8	1400,8
24	1 W	full moon (veil-clouds)	14,0	21,0	+7,0	14,2	9,8	6,23	158,1	9,78	33,1	209,8	1598,5
2	1 W	full moon (no clouds)	14,0	19,0	+5,0	13,2	9,2	6,48	142,8	—	35,7	255,9	1657,6
4	1 W	dawn	12,0	18,0	+6,0	5,7	4,0	6,61	60,5	—	35,3	274,4	1597,2
6	—	4	12,0	17,5	+5,5	5,2	3,7	6,68	56,2	10,10	33,5	312,5	1406,8
8	1	7	19,0	18,2	−0,8	7,6	5,3	6,58	81,5	—	34,6	286,8	1526,5
10	2 S	8	22,0	20,2	−1,8	10,5	7,3	6,36	115,6	10,48	37,9	176,3	1955,9
12	—	7—8	24,3	22,7	−1,6	12,4	8,7	6,07	144,1	10,33	34,6	272,1	1556,4

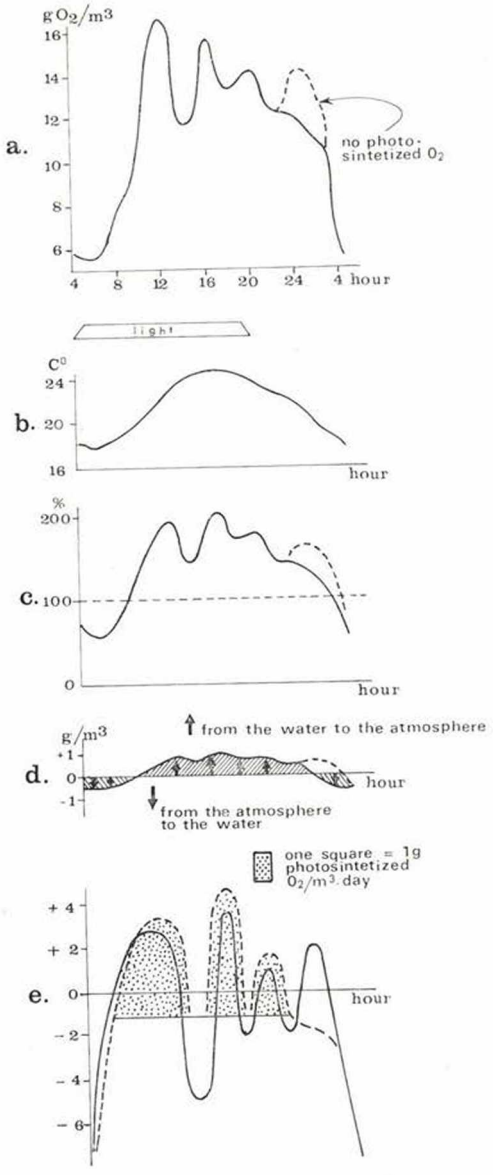

Figure 2. Primary production, respiration and diffusion in the water of Lake Nagyszéktó at Kistelek. (4 – 5. 6. 1955). (Curves constructed according to O d u m 1956, and O d u m, H o s k i n 1958). a) Dissolved O_2 quantity in water g/m³, b) Water temperature C°, c) O_2 saturation %, d) diffusion g/m³, e) O_2 change g/2 hours

region much richer in dissolved oxygen. This current of vertical direction not exposed to the influence of even the slightest wind, was quite marked at the time of the investigation. There is no production between 0 – 6 a. m. O_2-content is markedly decreased (decreasing autochtonous phase).

The water of Nagyszéktó contains a great quantity of CO_3^{--} ions in the summer months; thus CO_2, formed by dissimilation and used up by assimilation can be measured only indirectly, by determining the CO_3^{--} and HCO_3^- content of the water. Therefore the primary production of CO_2-free sodic waters may be described by the following two equations:

$$2\ NaHCO_3 \rightleftarrows Na_2CO_3 + H_2O + CO_2$$
$$6\ CO_2 + 5\ H_2O + 685000\ cal \rightleftarrows C_6H_{10}O_5 + 6\ O_2$$

It is obvious from these equations that if the assimilation intensity of the phytoplankton is more intensive than its dissimilation or the respiration of the zooplankton, the quantity of O_2 will increase, causing a simultaneous decrease of HCO_3^- and an increase of CO_3^{--}. If dissimilation predominates, the reaction will proceed in the direction of the lower arrow, thus causing an increase of HCO_3^- and a simultaneous decrease of CO_3^{--}; i. e. the pH value of the water will drop. Theoretically, the curves of dissolved O_2, pH and CO_3^{--} flow a parallel, that of HCO_3^- an antiparallel course.

The direction of the HCO_3^- plot does show this course antiparallel to the O_2-curve in practice however only in daytime. The HCO_3^- content of the Nagyszéktó water is increasing in the night hours till 12 p. m. at the same time also the O_2-content increases between 10 – 12 p. m. though this is not in accordance with the theory. However, as mentioned above, this increase in O_2 is of no biological significance since it is a mere physical phenomenon. The CO_3^{--} curve shows a run similar to the O_2-plot. But later another discrepancy is observed between the measured figures and theoretical considerations which has not been exactly solved yet. After the midnight hours the O_2-content of the water begins to decrease; thus a simultaneous increase of HCO_3^- and decrease of CO_3^{--} would have been expected. The measured figures, however, do not show this trend; on the contrary, the run of their plot suggests CO_2 consumption, however, without O_2 production. (A possible explanation of this phenomenon may be, that before the beginning of assimilation CO_2 gets into the inside of the alga cells by diffusion, causing the decrease of the HCO_3^{--} and a simultaneous increase of the CO_3^{--} content of the water during the night and in the early dawn hours.)

There is a great difference between the figures referring to some chemical constituent during a day. Differences between maximum and minimum values are as follows:

pH	=	0,7
O_2	=	11,5 mg/l
HCO^-	=	812,6 mg/l
CO_3^{--}	=	263,3 mg/l

Through the photosynthetic activity of the algae the momentary O_2, HCO_3^- and CO_3^{--} content, as well as the pH of the water in various parts of the lake are effected to a high degree by light conditions not only time but also in space.

To study this question, water samples have been drawn at the same time (6.6. 1955, noon) from three sampling spots of Lake Nagyszéktó. The three places are near one another, at distances of less than 20 m; the illumination conditions, however, display considerable variance as result of differences in vegetation. Sample spot 1. is in thre middle of the approx. 20 m wide reed-zone. This zone, with 2 – 2,5 m, high reeds, is located at the shore of the lake, with a water depth of 15 – 20 cm. Proceeding inwards to the middle of the lake, there extends a bulrush-zone of a width similar to that of the reed-zone. Bulrush *(Bolboschoenus maritimus)* is approx. 50 – 60 cm high thus overshadowing the water surface to a smaller degree; water depth in this zone varies between 20 – 30 cm. The second sampling spot is situated in, this zone while the third one is about 20 m inwards, at the uncovered about 40 cm deep area of water. In the following discussions these zones are called "reed-zone", "rush-zone" and "open water".

The results of the examinations (Table III. and Fig. 3.) present considerable differences in the chemical compositions of waters drawn from such relatively near places. Difference is especially marked among the O_2 saturation percentages of the three waters; this percentage is lowest in the reed-, higher in the rush-zone and the highest with the open water; the HCO_3^- values show changes in the opposite direction. The CO_3^{--} quantity also varies in a high degree: no CO_3^{--} is found in the reed-zone (pH = 8.42), but proceeding inwards

Table III.

Results of regional chemical investigations of Lake Nagyszéktó at Kistelek (12 h. 10. 6. 1955).

Temperature			Difference in favour of water	O_2 [mg/l]	O_2 [cm³/l]	Saturation [%]	pH	Alkalinity [W°]	CO_3^{--} [mg/l]	HCO_3^- [mg/l]
	of water [C°]	of air [C°]								
reed-zone	23,2	30,5	−7,3	0,6	0,4	6,7	8,42	39,7	0,0	2421,5
rush-zone	26,6	28,2	−1,6	1,4	1,0	17,8	9,78	34,5	280,9	1530,7
open water	27,6	27,2	+0,4	5,9	4,1	74,6	10,41	33,7	401,1	1240,3

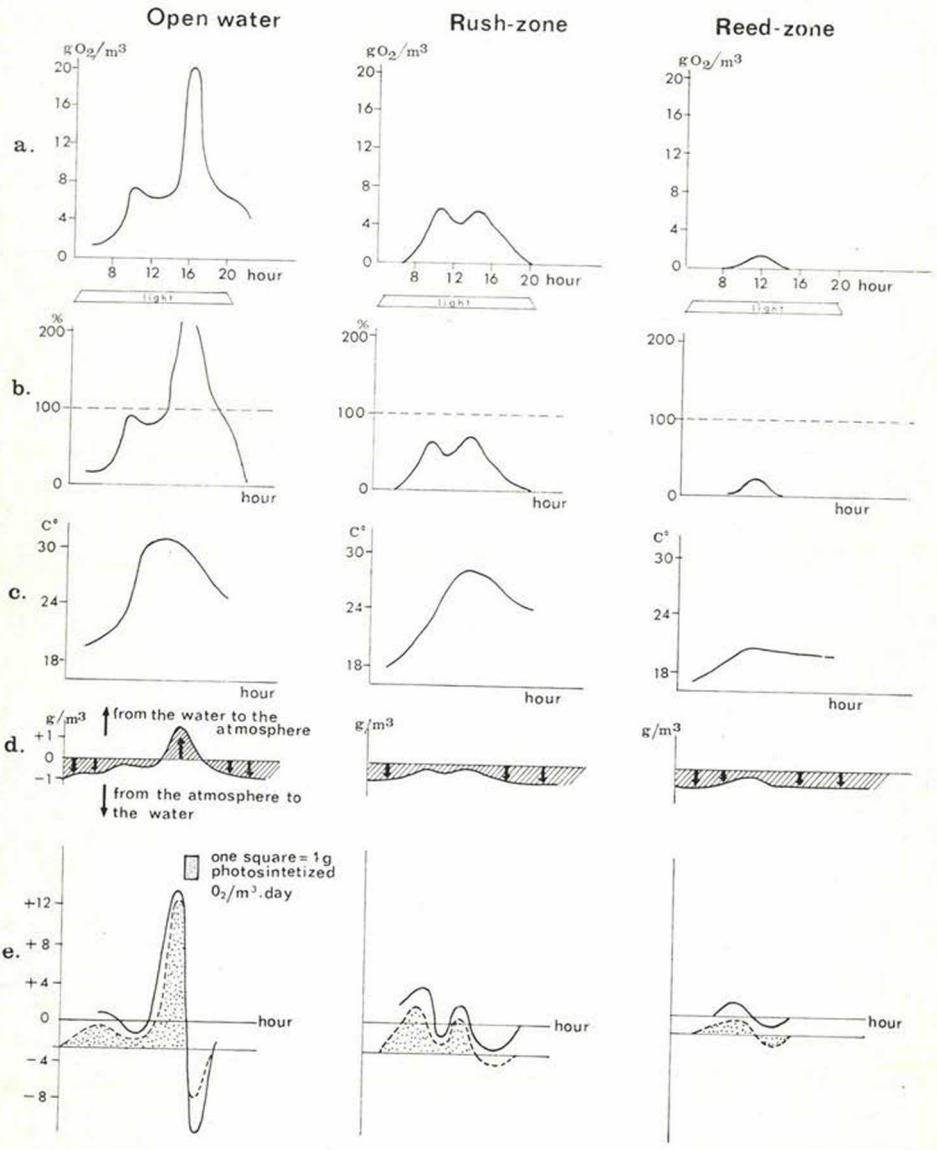

Figure 3. Primary production, respiration, and diffusion in the open water, in the rush zone and in the reed zone of Lake Nagyszéktó at Kistelek (11. 7. 1955). (Curves constructed according to O d u m 1956, and O d u m, H o s k i n 1958) a) Dissolved O_2 quantity in water g/m³ b) O_2 saturation %, c) Water temperature C° d) diffusion g/m³, e) O_2 change g/2 hours

to the centre of the lake its quantity increases also with the pH value an increasing tendency is observed.

Similar phenomena have been observed with the investigations of Lake Balaton, too: M e s c h k a t (1934) reports on the pH values at several points of the lake; these increase from 7,60 to 8,45 when one proceeds from the litoral reed-zone to the middle parts of the Balaton. I l o s v a y (1898) and E n t z (1953) pointed to the free CO_2-content of the water in the litoral reed-zone. According to E n t z and S e b e s t y é n (1940) the water of the reed-zone of Lake Balaton contains no suspended $CaCO_3$, a substance always found in the open water of the lake because it has been dissolved in the water of the reed-zone rich in CO_2; moreover, even a quantity of free CO_2 is found in this type of water though. Under ordinary circumstances Lake Balaton contains no free CO_2. (F e l f ö l d y and T ó t h, 1957; T ó t h 1959). This phenomenon may be a caused by two factors: (i) only a reduced assimilation of autotrophic organisms is possible in this zone because of the low illumination (shadowing of the reed) (ii) the decomposition of the detritus at the bottom of the reed-zone is a rich source of CO_2.

The results achieved by the regional investigation of Lake Nagyszéktó can be explained similary to those obtained with Lake Balaton. However, it is worth attention that while these characteristic differences in the chemical constitution of the water of Lake Balaton are separated by distances of several hundred meters, the places of similar chemical differences in Lake Nagyszéktó are near another (20 meters).

Daytime O_2 production and the corresponding values of 3 spots of the lake, having different illumination conditions, are given in Table IV. (11.7.1955). In the reed-zone a twilightlike illumination prevails during the whole day; the light is generally not enough to satisfy the demand of assimilation. This clearly appears in the oxygen content of the water: except the period between 8 a.m. – 2 p.m. O_2 is completely absent.

The lack of light is not so pronounced in the rush-zone, though as regards assimilation the "day" is shorter there than in the open water. O_2-production begins at 8 a. m. and ends at 6 p.m. Illumination is above the optimum at noontime, as shown by a depression of the O_2-curve which is followed by a second, higher peak. As compared to the O_2-curve the change in HCO_3^- content shows an opposite run. Even higher changes occur in the CO_3^{--} content of the lake: it cannot be detected in the reedzone, independently of the time of sampling. On the other hand, in the rushzone it is present during the whole day, in a maximum quantity at noon (fivehold of the morning value). In the open water, however, a noon-time local minimum occurs, followed by an outstanding maximum at 4 p.m. and a gradual decrease late in the afternon. The CO_3^{--} content vs. time plot is thus rather similar to the O_2 vs. time plot. In the reed-zone pH is relatively constant all day long, with a value just below the stability limit of CO_3^{--}; the plot shows a

Results of regional chemical investigation of Lake Nagyszéktó Kistelek (11. 7. 1955). *Table IV.*

Time [hr]	Wind	Cloudiness (cumulus clouds)	Air pressure [mm Hg col.]	Place	Temperature		Difference in favour of water	Light intensity [lux]	O_2 content		Saturation		pH	Alkalinity W°	CO_3^{--} mg/l	HCO_3^- mg/l
					air [C°]	water [C°]			mg/l	cm³/l	cm³/l	%				
6	1 NWW	9,5	756,5	reed-z.	21,0	17,2	−3,8	700	0,0	0,0	6,72	0,0	8,43	81,9	0,0	5001,4
				rush-z.	23,2	18,0	−5,2	1 100	0,0	0,0	6,61	0,0	9,73	60,2	190,7	3282,3
				open w.	20,1	19,3	−0,8	3 000	1,4	1,0	6,44	15,5	> 10 48	52,0	304,5	2556,3
8	1 W	3 – 4	757,0	reed-z.	23,2	18,1	−5,1	3 200	0,0	0,0	6,60	0,0	8,43	80,0	0,0	4882,3
				rush-z.	23,3	19,5	−3,8	6 000	1,8	1,3	6,42	20,3	9,73	68,3	510,4	3129,8
				open w.	21,3	20,8	−0,5	> 10 000	2,2	1,5	6,26	23,9	> 10,48	63,4	1028,8	1775,4
10	1 NW	6	756,5	reed-z.	26,5	20,3	−6,2	8 000	1,1	0,8	6,32	12,7	8,43	87,1	0,0	5318,9
				rush-z.	28,1	22,1	−6,0	> 10 000	5,5	3,8	6,10	62,3	9,82	71,6	679,1	2989,5
				open w.	28,4	22,2	−6,2	> 10 000	7,2	5,0	6,09	82,1	> 10,48	67,7	1127,9	1836,4
12	1 WWN	6 – 7	756,5	reed-z.	27,6	23,8	−3,8	6 000	1,4	1,0	5,91	17,4	8,43	80,0	0,0	4882,3
				rush-z.	27,6	25,3	−2,3	> 10 000	4,2	3,0	5,75	52,5	9,64	68,9	749,6	2684,4
				open w.	29,9	29,8	−0,1	> 10 000	5,8	4,1	5,28	77,7	> 10,48	59,2	902,5	1775,4
14	1 NWW	7	756,5	reed-z.	31,6	22,9	−8,7	3 800	0,0	0,0	6,01	0,0	8,43	89,1	0,0	5437,9
				rush-z.	29,0	28,1	−0,9	> 10 000	5,5	3,9	5,45	71,6	10,48	69,9	824,5	2586,8
				open w.	29,8	30,2	+0,4	> 10 000	6,1	4,2	5,24	80,1	> 10.48	63.6	854,0	2147,5
16	1 NEE	9	756,0	reed-z.	25,6	22,4	−3,2	3 000	0,0	0,0	6,07	0,0	8,43	74,8	0,0	4564,6
				rush-z.	26,3	26,9	+0,6	5 600	3,1	2,2	5,57	39,6	9,73	58,6	447,3	2666,1
				open w.	26,1	29,1	+3,0	> 10 000	19,9	13,9	5,35	241,1	> 10,48	54,6	1167,4	057,9
18	1 NNE	4 – 5	756,3	reed-z.	24,9	21,8	−3,1	2 400	0,0	0,0	6,13	0,0	8,43	74,2	0,0	4524,9
				rush-z.	27,6	25,3	−2,3	5 000	0,4	0,3	5,75	5,2	9.64	71,6	363,2	3630,1
				open w.	26,5	27,2	+0,7	> 10 000	7,9	5,2	5,53	94,1	10,48	55,9	1128,6	1116,5
20	1 N	2	756,7	reed-z.	21,9	20,9	−1,0	200	0,0	0,0	6,24	0,0	8,43	80,7	0,0	4921,9
				rush-z.	26,8	24,2	−2,6	700	0,0	0,0	5,87	0,0	9,55	59,2	345,1	2910,2
				open w.	24,7	25,3	+0,6	1 400	6,2	4,4	5,75	7,7	10,48	52,4	909,7	1348,3

bell-like run in the rush zone; similarly to the CO_3^{--} curve it presents a double-peaked run with a local minimum in the open water.

The difference between the maximum and minimum values during the examination are shown in the following table:

Table V.

	pH	O_2 mg/l	HCO_3^- mg/l	CO_3^{--} mg/l	Alkalinity W°	Illumination lux	Temperature C°
reed-zone	0,0	1,4	913,0	0,0	14,9	7800	6,6
rush-zone	0,9	5,5	1043,3	633,8	13,0	> 8900	10,1
open-water	1,1	18,5	1598,4	862,9	15,7	> 8600	10,9

It is obvious from the data that O_2 produced during assimilation, or used up during dissimilation and respiration is in all instances lower than the change of opposite direction in the quantity of HCO_3^-. In other words: relatively low changes in O_2 involve high fluctuations of the HCO_3^- content. (As the water of the lake is usually supersaturated with O_2 in the periods when the measurements were conducted, it may be assumed that diffusion has a significant role too. O_2 content is thus considerably higher than supposed relying upon the tabulated data.)

It should be borne in mind that at the diurnal or partdiurnal examinations neither preceding events, nor quantitative factors of an already existing equilibrium are known; on such occasions it is, namely not a course of development which is gradually examined only the intensity of biological processes is deduced from the chemical changes of the water. Consequently a lot of important data remains unknown: the energy accumulated in the phytoplankton during former periods, the O_2-consumption of the zooplankton and its change with varying temperature, etc. — i.e. the quantitative values and changes of the other factors of equilibrium.

Thus the results of the diurnal and part-diurnal examinations are not characteristic of the primary production, only of the resultant of the gross biological processes in the lake. Information on the absolute quantity and direction of the chemical processes caused by the phyto- and zooplankton and other constituents cannot be obtained from the diurnal $O_2 - CO_2$ changes, however, the investigation data being a resultant of all changes, are sufficient to decide, whether at a given time assimilation or dissimilation processes preponderate and to what extent. If the changes in O_2 and CO_2 are not great, it may be said that the intensity of biological processes in the water of the lake is low, the other possibility: processes of high intensity but with a similar mea-

sure of assimilation and dissimilation can be excluded, as this condition is unstable for longer periods.

However, not the state of low O_2-CO_2 changes is characteristic of Hungarian sodic waters; on the contrary the dynamics of the O_2-CO_2 household is rather intensive in them.

O d u m' s (1956) as well as O d u m and H o s k i n' s (1958) methods have enabled the estimation of the primary production of the Nagyszéktó Lake founded on the results of our earlier diurnal investigations. The biotope of the lake is rather heterogeneous, i.e. plankton-, bethos- and periphyton organisms are all prducents, moreover in litoral zones even higher plant organisms have an important role. All these facts justify the application of a method where primary production is not estimated by black-and-light-bottle data, but by registrating the diurnal O_2-changes, measured directly in the water of the lake.

Gross primary production and respiration were determined graphically, based on the diurnal O_2-curves, as shown in Figs. 2. and 3. As O_2-saturation was rather variable in all instances during the day, also the O_2-exchange between the water and the atmosphere i.e. the rate of diffusion was calculated for each hour, and the production curves were corrected with these values. Production, respiration and their quotient are presented in Table VI.

Table VI.

Primary production (P), respiration (R) and P/R values of Lake Nagyszéktó at Kistelek.

	Gross primary production g $O_2/m^3 \cdot day$	Net primary production g $O_2/m^3 \cdot day$ (P)	Respiration (R) g $O_2/m^3 \cdot day$	P/R
Open water				
4–5. 6. 1955.	88	44	24	1,8
11.7. 1955.				
Open water	118	26	72	0,4
Rush zone	112	13	89	0,14
Reed zone	72	4	48	0,08

These data, as compared to other estimations of productivity made by similar methods, definitely show that production intensity in the open water of the Nagyszéktó Lake is exceptionally high, much higher than those of the shallow fresh- and brackish waters of Europe and America, studied by various authors (S p o d n i e w s k a 1969, F o t t 1972, O d u m, O d u m 1955, M c C o n n e l l 1962, O d u m

1957 Odum, Hoskin 1958, Welch 1968, Copeland, Dorris 1962, Guning, Wulff 1970). Diffusion values correspond to the values published about shallov waters, estuaries, ponds stirred up by the wind etc.

The most important index for the assessment of production is the quotient primary production/respiration or, in other words, the ratio of production to consumption. In periods during which production outpaces consumption, organic substance will accumulate, while on other days it might be totally consumed.

In the aqueous community of the Nagyszéktó lake production was dominant among the most favourable meteorological conditions prevailing at the time of the examination: gross production and the production/respiration ratio were both highest in the open waters of the lake. Diurnal changes in O_2, saturation, as well as O_2-exchange were highest similarly in the open water; in the reed- or bulrush-shadowed areas production/respiration ratios considerably decreased. There O_2-saturation is lower- diffusion takes place in one direction only (from the atmosphere to the water), and is almost constant during the day.

Unfortunately a repetition or extension of these studies became impossible. Together with other sodic lakes in the melioration programme of the last years, the aged Nagyszéktó Lake (of 7 sq. km surface) was drained and reclaimed. However, there are still smaller sodic lakes to be found in Hungary where further O_2-examinations are possible.

It is hoped that thses examinations will serve as a basis for comparison with other waters of different chamical character, and can be evaluated with respect to other sodic waters similarly of vigorous material- and energy household, as suggested by Project Aqua (Luther, Rzóska 1971).

Summary

The chemical composition of sodic lakes shows high daily and annual changes. From the changes of the chemical components (in the first place O_2, HCO^-_3, CO^{--} as well as pH) conclusions can be draw on the intensity of the biological alterations taking place in the water of the lake. In periods when the assimilation of the phytoplankton is higher than its dissimilation and the respiration of the zooplankton, the dissolved O_2 content increases, and HCO^-_3 decreases consequently the CO^{--}_3 content of the water increases, and *vice versa*.

The biological processes vary in intensity at the differently illuminated places of the lake: water samples taken in spots near one another, but of different conditions of illumination are utterly dissimilar in chemical respect.

In the reed-zone one could conclude on a deficiency of light from the O_2 content of the water: a total absence of O_2 was found there, with the only exception of the late morning and noon hours. Deficiency of light is not so distinct in the rush-zone, still, the "day" (as regards illumination) is much shorter there than in the open water. The content in CO_3^{--} and the pH change parallell with the alternations of O_2, HCO_3^- changes in a direction opposite to same.

The amount of O_2 produced during asimilation and that used up in the course of assimilation are at all times lower than the simultaneous opposite changes in HCO_3^-, i.e. low changes in O_2 are concomitant with disproportionately high ones in HCO_3^- content.

At the time of examinations discussed here the production of the community preailed in the Nagyszéktó lake: gross production and the production/respiration ratio were highest in the open water of the lake. These values are much higher than the ones in the shallow fresh- and brackish waters of Europe and America studied by various authors engaged in research work on the subject. Similarly, O_2 -changes between the atmosphere and the water were highest in the open water of the lake. In areas shadowed by reed and bulrush markedly decreased production/respiaration values could be observed. Diffusion took place there only in one direction (from the atmosphere to the water) and was almost constant during the day.

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